ANNUAL REPORT

LAKE STATES FOREST EXPERIMENT STATION
FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE

E. L. DEMMON, DIRECTOR

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LAKE STATES FOREST EXPERIMENT STATION

ANNUAL REPORT FOR 1949

INTRODUCTION

A research organization, like a business, must take stock periodically. For this reason the Lake States Forest Experiment Station, since its establishment in July 1923, has made an annual review of its program. Each year the station examines all its projects critically to see if the most important regional forestry problems are under study; if there is proper coordination with other units working in the same or allied fields; whether the program is developing the information most needed by public agencies, private companies, farmers, and other forest landowners to build sound forestry practices; and whether its research results are made available by prompt publication.

Emphasis on Regional Problems

Most of the Station's forest research projects are of a long-time character which, once started, cannot be dropped on short notice without considerable loss; and furthermore, they are primarily concerned with problems of regional significance. Like the eleven other federal forest experiment stations in the country, the Station is responsible for carrying the federal share of forest research in a specific region - in this case, the Lake States.

Decentralization of Field Work

While research at the Station emphasizes regional problems, much of the field work is located on experimental forests and is directed from local offices called research centers. Four of these research center offices have been set up in the three Lake States - at Grand Rapids, Minnesota; Rhinelander, Wisconsin; and Marquette and East Lansing, Michigan. Six experimental forests have been established and others are in the process of being set aside for research purposes. The only portion of the region which has no research center is the Upper Mississippi woodlands area of southern Minnesota and southern Wisconsin, comprising 8-1/2 million acres of forest land (15 percent of the forest area of the Lake States). North Dakota is also nominally in the Station's territory, but the research program initiated there some 15 years ago is now on a bare maintenance basis due to curtailment of funds.

Specialization at Research Centers

The three Lake States in certain respects are fairly homogeneous, in others, widely divergent. From a topographic standpoint there is great similarity. Level to rolling country is the general rule, with few steep hills and no real mountains. Despite local variations due largely to the Great Lakes, rainfall and mean temperatures decrease fairly steadily from southern Michigan to northwestern Minnesota. Consequently, there is some tendency for the various hardwood and coniferous forest types to be arranged in continuous broad bands to fit the climate. However, because of the great diversity of soils and drainage, largely the result of past glaciation, the forest types have a decidedly spotty distribution, without, of course, any relationship to state boundaries.

Although pine forests occur patch-wise in all three states, the greatest concentration of pine is in the Headwaters province of Minnesota (near the headwaters of the Mississippi River and the streams flowing into Lake Superior and the Hudson Bay drainages). Accordingly, the research program of the Station in the management and regeneration of pine, particularly jack pine and red pine, is emphasized there. Such work as is undertaken on pine management problems in other parts of the region is minor and includes only small tests to determine the applicability of findings made in the Headwaters area.

The greatest concentration of old-growth northern hardwoods is in the Upper Peninsula of Michigan, and studies relating to this type are centered there, but the results will in a large measure be applicable elsewhere in the Lake States region. In like manner, particular attention is being given to forest plantation management in lower Michigan because the great bulk of older plantations is concentrated in this area, but findings should have fairly general application elsewhere in the region. Second-growth northern hardwoods are receiving most attention at the Northern Lakes Center in Wisconsin. Thus, by careful analysis of existing forests and their problems, unnecessary duplication of research in several states is avoided.

Cooperative Efforts in Forest Research

Most forest problems involve a complex interaction of biological, physical, and economic factors. Many of them cannot be solved by any one agency but require the joint effort of experts in several fields. The cooperation of many federal, state, and private agencies is essential for maximum progress in their solution. That the Station has recognized this is indicated by the fact that in 1940 it had three cooperative research agreements in effect; whereas in 1949 there were ten. In 1940 the Station received direct cooperation valued at $8,700; in 1949, $88,600. In 1940, state and other agencies spent about $22,500 on forest research closely correlated with the Station program; in 1949, this had risen to $52,200. Altogether there has been a four-fold increase in cooperative research effort in this region in the past nine years, a very healthy trend.

General Resource Situation

Recent forest-survey findings, combined with the results of surveys made by the Station prior to 1937, have been summarized for the Lake States region in a report, "Forest Resources and Forest Industries in the Lake States," now awaiting publication as a government bulletin. Indications are that the total wood growth now is almost in balance with drain. However, compared to the original forest the present one has more small trees and low-value species, often of poorer quality. This, along with complicated ownership, presents special problems in utilization and management.

Although interest in forestry in the Lake States has expanded considerably in the last few years, much remains to be done towards improving forest production. Actually, present forests are growing at less than half their capacity under good forest management. The Station's program is aimed to provide information on forest practices needed for optimum forest land use for all purposes. However, getting recommended practices into effect is largely the job of other agencies.

As will be discussed later, the Forest Survey continues under way on a cooperative basis in Michigan and Minnesota. Interest has developed during 1949 to have the Forest Survey initiated in Wisconsin, but the Station's contribution to any new program there must depend on availability of funds.

Forest Products Utilization Studies

As yet, the Lake States region has not been provided with a forest utilization service unit, as have all other important forest regions in the country. However, the Station is receiving an ever increasing number of requests for help in this field. Such a service would provide a connecting link between the Forest Products Laboratory at Madison, Wisconsin, and the forest products industries and other timber growers and users in the field. Primary functions of a forest utilization service are:

1. To analyze the wood-using problems of a region and to determine the best approaches to problem solutions.

2. To present these problems to the Forest Products Laboratory, or to other qualified agencies, for research.

3. To improve forest utilization practices by bringing present technical knowledge and the results of further research to the industries, wood users, and timber growers.

Status of Knowledge on Reforestation

Because of increased interest in forest planting and proposals to speed up the restoration of denuded lands, an examination of the status of

knowledge on the biology of seed, nursery practices, and planting methods seems appropriate. Because of the importance and timeliness of this subject, major emphasis in this annual report will be placed on a review of the Station's reforestation research program.

In addition, brief summaries will be included of accomplishments on other Station projects during 1949. Since most Station studies are long-time in character, conclusive results cannot be expected every year from each project.

Plans for 1950 contemplate continuation of current work and expansion into fields of recognized need as rapidly as facilities justify.

FOREST MANAGEMENT

Reforestation

The urgent need for reforesting denuded and poorly stocked forest land was recognized by Congress in 1949 by the passage of the Anderson-Mansfield Act, which authorizes an increased rate of reforestation on the national forests. The State governments of Michigan, Wisconsin, and Minnesota have also shown awareness of the problem by increasing forest nursery output. Furthermore, despite increased costs of planting stock and labor, the development of planting machines has resulted in increased tree planting by the pulp and paper companies and others.

Forest planting is of prime importance in the Lake States region where it is estimated there are 12-1/2 million acres of forest land (more than half of it privately owned) in need of reforestation. Federal nursery capacity could readily be expanded to increase planting stock production for the national forests. The impending accelerated program makes it advisable to review research progress on reforestation problems. More specifically, what knowledge has the Lake States Forest Experiment Station contributed to provide a sound basis for a large reforestation program and in what particular fields is more information needed to assure more effective and economical restoration of our forests?

Reforestation involves many problems - the procurement of adequate supplies of good seed of proper origin, the development of sturdy nursery stock and its outplanting in the field and bringing established plantations into production. The Station has contributed to each phase of this process.

Seed - The Beginning of the Forest

Most forest trees start from seed, whether artificially or naturally regenerated. Therefore, reliable information is needed as to the time of seed ripening and the proper time for its collection, behavior of the seed after planting (whether germination is prompt or delayed by dormancy), viability, storage of seed of those species which bear infrequent crops, and pretreatment to induce prompt germination.

For this reason, the Station included seed studies as one of its earliest projects. Over a period of 20 years, more than 4,000 tests were run on seeds of some 270 different trees and shrubs. Information from these tests was combined with that from other forest experiment stations and forestry agencies and added to authentic information from nearly 400 published articles to produce the "Woody-Plant Seed Manual" recently published by the Forest Service.1/

This 416-page manual consists of two main parts - Part I formulates general principles on the various phases of seed handling from formation of the seed to sowing. Part II, which forms the larger part of the manual, provides relatively detailed but concise information for 444 species of trees and shrubs of value in the United States; this includes data on distribution and use, discussions of seeding habits, methods of seed collection, extraction and storage, seed germination, and nursery and field practice. Although many of these species and varieties are not yet in wide use, all are of potential value for conservation planting.

This manual is, in a sense, the first step toward organization of the whole tree-seed enterprise on a sound and scientific basis, and for this reason it should be of interest not only to public agencies but also to seed dealers, horticulturists, and commercial nurserymen.

The Station took a leading part in producing the seed manual. Members of the Station staff planned and initiated it, supplied much unpublished data, wrote many parts of the manuscript, supplied much of the material for drawings, and gave its preparation over-all direction.

While the issuance of the Woody-Plant Seed Manual is a milestone and while it does provide sufficient seed information on which to base a large-scale program of reforestation, it does not follow that seed research is completed. On the contrary, the manual shows up many places where further information is needed, and there are some 250 other species of known conservation value in the United States for which seed information is lacking.

From Seed to Seedling in the Nursery

A great deal of experience has been built up over the past two decades in operating public forest nurseries in the Lake States. Considerable intensive research has also been conducted. Now the experience and the research are being combined in a nursery manual which is under preparation jointly by the Station and Region 9 of the Forest Service. This manual was begun before the war but was put aside until recently for matters considered more urgent.

1/ *U. S. Department of Agriculture Miscellaneous Publication No. 654. For sale by Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. Price - $2.75.*

Two nursery studies have been completed recently. The first, dealing with the use of mineral spirits for killing weeds in conifer nurseries, was reported in Station Paper No. 17, although preliminary results were given in the Annual Report of the Station for 1948. The important finding was that small weeds can be controlled successfully in conifer nurseries by careful application of mineral spirits and at a substantial savings in labor costs.

The second study showed how to correct excessive soil acidity built up in conifer nurseries by repeated use of sulphuric acid and peat. Finely-ground limestone was raked into the soil between the drills on an area of fall-sown first-year jack pine in which a third or more of the trees were badly off-color. The soil was a fine sand with about 10 percent of silt plus clay. Within 10 weeks after treatment, considerable correction of the condition had occurred even in the lightest treatment as shown in the following table:

Ground limestone applied per acre	Trees yellow due to excessive soil acidity		Increase or decrease in yellow trees	Soil acidity in top 4 inches on Sept. 28, 1948	Total fresh weight of 100 trees
	July 27, 1948	Oct. 6, 1948			
Pounds	Percent	Percent	Percent	pH	Ounces
0	32.6	56.2	+23.6	4.11	8.00
500	39.8	29.0	-10.8	4.60	9.50
1,000	42.4	19.3	-23.1	5.03	10.10
1,500	42.9	17.4	-25.5	5.25	11.20
2,000	34.4	12.6	-21.8	5.51	8.85

Where ground limestone was worked into the soil just before seeding, damping-off reduced the tree stand by 20 percent. A safer treatment would be to apply limestone to areas on which cover crops, such as legumes or transplants, were to be grown for several years. Limestone should be applied to seedlings only after the stems are past the soft succulent stage, that is, after the seedlings are at least 10 weeks old. In larger-scale treatment of seedbeds, the material could be worked into the soil with weeding or cultivating equipment.

Based on tests to date, 500 to 1,500 pounds of ground limestone per acre is a conservative treatment, using the lighter amount where minor adjustment of pH is necessary, and the heavier amount for the more acid areas. Treatment with limestone may create a temporary shortage of available nitrogen and may require application of a liquid nitrogen fertilizer to the trees.

How to Plant Trees

Because of the large area of forest land denuded by logging and destructive forest fires in the early days, forest planting was one of the first technical forestry activities undertaken by federal and state forestry agencies

in the Lake States. Reforestation research also was one of the first projects undertaken by the Lake States Forest Experiment Station.

Since 1876, about 1-1/2 million acres have been planted to trees in the Lake States and a large fund of experience has developed. During the past two decades the Station has carried out many planting studies. The results of these studies, leavened with those of experience, have been worked into a comprehensive manuscript, "Forest Plantations in the Lake States," now in Washington awaiting publication as a technical bulletin. The manuscript gives research results and practical guides as to what to plant, when to plant, where to plant, how to plant, how to care for plantations, what enemies to guard against, and how to plan large-scale reforestation. Special sections are devoted to direct seeding, conversion planting of aspen and brushlands, planting for wildlife food and shelter, and erosion control planting.

A less technical manuscript, "Tree Planting in the Northeastern States and the Lake States," has been prepared in collaboration with the Northeastern Forest Experiment Station and submitted to Washington for publication. It is designed especially to guide the small landowner or farmer who wishes to plant forest trees.

Much of the current interest in forest planting investigations is in ways and means of reducing costs. High labor costs in particular have stimulated the development of planting machines and other mechanical equipment. Three studies in this field have shown promise the past year:

1. On certain sites that sprout back to a heavy cover, use of drastic mechanical methods to prepare the site for planting may be necessary; otherwise, high subsequent investment in release is required.

   A test of various degrees of disking in comparison to furrowing was established in 1945 and 1946 on three different types of brushy and difficult planting sites in cooperation with the Chippewa National Forest. These were a red pine site which had been invaded by brush following clear cutting, an open jack pine site made brushy by repeated fires, and a severely burned aspen site. Tested were moderate disking, heavy disking, moderate disking followed by redisking the following year, and heavy disking and redisking. All ground preparation was done in August and the areas were planted the following spring with red pine.

   A reexamination of the plantations made in the fall of 1949 after four to five growing seasons, showed that disking prior to planting in very brushy areas is a better method of ground preparation than furrowing for the particular sites in question, and that heavy disking or redisking the second season are of doubtful value.

2. Use of mechanical equipment to prepare sites for direct seeding of balsam fir also offers advantages as shown by an experiment in

northeastern Wisconsin. Here disking and seeding were done in May 1948 by several methods on a former hardwood site, with a cover of about 50 pole-sized aspen per acre. The average number of balsam fir seedlings and aspen per milacre of disked land at the end of the second year is shown below:

Method of covering seed	Balsam fir		Aspen	
	Milacre quadrats stocked	Average stocking per milacre	Milacre quadrats stocked	Average stocking per milacre
	Percent	Number	Percent	Number
Not covered	37	1.35	99	7.99
Covered by scrape of foot . .	46	1.60	97	5.95
Covered with brush drag . . .	35	0.99	98	7.79

Only 50 percent of the ground was actually covered in disking, so the number of balsam fir seedlings per acre was 495 to 800.

On the above job costs per acre were about as follows: Disking $3.00; labor $1.44 (with seed covering by foot); seed $1.20; or a total of $5.64. This is about one-third or less of the present-day cost of planting.

Plantings of white spruce and balsam fir transplants on adjacent disked areas gave average second-year survivals of 98 and 93 percent respectively on the aspen site, with spruce showing better vigor and height growth.

Disking to stimulate aspen sprouting and seeding in badly understocked aspen stands, along with some "sweetening" by seeding of balsam fir, offers promise as a possible low-cost method of regenerating such lands, but not necessarily a substitute for planting which is almost certain to produce a stand of more value.

3. Disking may offer a good possibility for rehabilitating understocked hardwood stands resulting from fire, overcutting, or grazing. For example, in May 1948, a scattered stand of second-growth hardwoods on the Argonne Experimental Forest in northern Wisconsin was double-disked with an Athens type disk at a cost of about $6 per acre. Some 60 percent of the mineral soil was exposed after treatment. The soil with a silt loam and the ground cover was 10 percent hazel brush and 90 percent grass, mostly red top, timothy, and quack grass. In the first season after disking, a heavy crop of nettles about three to four feet high covered the area. It was shorter and less dense in 1949. By the fall of 1948, the area had 40 percent stocked quadrats with 1,120 new seedlings per acre. The following spring (1949) a

tremendous crop of seedlings came up and by that fall there were some 18,500 trees per acre with 94 percent stocking. The percentage composition of the seedling reproduction was as follows: sugar maple 94.5, aspen 2.6, black cherry 1.2, yellow birch 1.0, red maple 0.6, and American elm 0.1.

Although progress has been made in the application of mechanical methods of ground preparation for reforestation, this is a field that needs further investigation. Combining mechanical and chemical methods needs particular attention.

Another line of work needing more consideration is site evaluation for planting. General guides are available and fairly specific ones can be had for certain localities, but there is need to cover more of the region. Much of this can be worked out in collaboration with soil specialists of the State universities.

Insects and diseases are a plague to the forest planter and continuing progress of research directed toward measures that will insure future plantations as insect-free as possible is important. However, more specific control measures for the immediate problems in existing plantations should not be overlooked.

Plantation Management

Notwithstanding the extensive areas of forest land in the Lake States needing planting, notable progress has been made in restocking deforested areas. There are about one million acres of successful plantations (mostly pine) in the region, and nearly half of them are in the Lower Peninsula of Michigan. While nearly four-fifths of these plantations are under 20 years of age, most of them are in need of some cultural treatment.

Many plantations, especially those of red and white pine, were established on areas that already supported varying amounts of forest growth where the cover aided in the survival of the pine. Usually this cover was poor quality aspen or oak that contained few or no merchantable products. At present, these plantations need release from the overtopping hardwoods if the pine is to survive and develop satisfactorily. There is immediate need for more information on methods and timing of plantation release to obtain optimum success at least cost. Possibilities of many nonpoisonous chemicals in the removal of overtopping hardwoods need study.

From a survey made of 27 released plantations of red and white pine in lower Michigan, it was found that prolific oak and aspen sprouts soon overtopped the young pine again. The height growth of aspen, oak, and red maple sprouts was two to four times that of the red and white pine. The success of a release operation depends primarily on the ability of the planted trees to keep ahead of sprout growth resulting from the trees cut. With present conventional axe methods at least two releases

will usually be necessary unless chemical-control methods can be devised to prevent sprouting.

The relation of age to response following release of red and white pine is not fully known. White pine up to 30 years of age made increased height growth after release. Red pine up to 11 years old also responded to release, but a 30-year-old plantation did not respond in five years after release. These preliminary results should be substantiated by controlled experiments.

Plantations on medium sites which are not overtopped will contain trees of merchantable size when 25 to 30 years old, so that thinnings will be desirable both to improve growth and to obtain pulpwood, cabin logs, and posts. Many plantations will need thinning in the next 10 to 20 years. Research should supply information as to proper methods and timing of thinning for best growth and highest financial returns. One illustration of the results of thinning was shown in two thinning plots established by the Michigan Department of Conservation in a 27-year-old red pine plantation in the Lower Peninsula, planted rather densely. The stand condition after thinning in 1939 and 10 years later was as follows:

Year	Thinned, per acre			Check, per acre		
	Trees	Basal area	d. b. h. average tree	Trees	Basal area	d. b. h. average tree
	Number	Sq. Ft.	Inches	Number	Sq. Ft.	Inches
1939	620	65	4.4	1,524	131	4.0
1949	620	142	6.5	1,460	191	4.9

The dominant trees in the thinned stand grew 2.5 inches in diameter in 10 years, while the dominant trees on the unthinned plot grew but 1.3 inches. Height growth was not affected by thinning. The cubic volume of trees 5 inches d.b.h. and larger was about equal on both plots 10 years after the first thinning. Hereafter considerably faster growth in merchantable volume can be expected in the thinned plantation.

Past experience has shown that high-grade lumber or veneer cannot be obtained from plantations with the usual spacings and in the length of time desired. In order to obtain a product free from knots in less than 100 years, pruning must be practiced. Thus far, few pruning studies have been made in the Lake States. There is need for more experimental work to test the recommendations made in other regions, and to obtain information directly applicable to the Lake States region. Methods and costs of pruning red, white, and jack pine, by site classes need to be explored. Studies aimed at the solution of these problems are now being started.

Summarizing the state of knowledge on forest planting, it appears that there is a substantial amount of factual information on which to go ahead with a large-scale reforestation program. Naturally there are many gaps, and efforts should be made to fill these as rapidly as possible, but enough is known now to give reasonable assurance of success.

Other Studies in Forest Management

Research in reforestation represents only a part of the Station's studies in the general fields of silviculture and forest management. While it is highly important to know how to reforest denuded and poorly stocked lands, it is also necessary to know how best to handle existing forests. A few findings in these fields made during 1949 are reported here.

Does Partial Cutting of Northern Hardwoods Result in Inferior Reproduction?

The quality of reproduction following partial cutting of northern hardwoods compares favorably with that produced after clear cutting. This is true, at least, for 5 cuttings established between 1927 and 1929 on the Upper Peninsula Experimental Forest in Michigan. A summary made in 1948 of all living reproduction of merchantable species ranging from 0.6 inch d.b.h. to 20 to 30 feet high on randomized strips on six cuttings and a reserve area is given at the top of the following page.

The number of all-around good trees per acre falls off some for the lightest cutting, but even here there are sufficient trees for a satisfactory future stand. The proportion of good trees increases regularly from clear cutting through light improvement cutting.

The proportion of good trees when a single attribute only is considered is usually higher than the proportion of all-around good trees for a given cutting, because some trees are good in one attribute and poor in another. In origin and position the lighter cuttings excel; in form and condition there is little variation; and in clear length the heavier cuttings are slightly superior.

Number and Proportion of Good Reproduction Per Acre in 1948 1/

Degree of cutting (in percent of gross board-foot volume)	Total reproduction per acre	Good reproduction per acre 2/		Proportion of reproduction with good attributes 3/				
		Number	Proportion	Good origin	Good position	Good form	Good condition	Good clear length
	Number		Percent		Percent			
100	1,558	414	27	60	58	81	89	64
90	1,226	420	34	72	55	85	90	69
62	984	394	40	76	59	83	97	63
46	774	414	53	86	73	83	94	62
24	506	310	61	90	89	85	89	55
No cutting (reserve)	640	340	53	96	82	75	85	55
Group cutting	1,130	522	46	87	64	77	94	53

1/ Based on 0.5-acre tally from each cutting.
2/ Good in origin, position, form, and condition. Clear length not considered because of the young age of these trees.
3/ Good origin means seedling or seedling sprout; good position means dominant, codominant, or intermediate; good form means straight to moderately crooked; good condition means vigorous with no rot; and good clear length means free of branches for at least half of length.

Employment Possibilities of a Northern Michigan Forest

The employment possibilities of a given tract of forest land are an important and intriguing aspect of forest management. Several years ago, growth on the Upper Peninsula Experimental Forest was estimated to be 85 board feet per acre per year for the 4,700 acres then in government ownership. Well-stocked and poorly stocked old- and second-growth northern hardwood stands, coniferous and hardwood swamps, and unproductive open lands were included in this acreage. This growth provides an annual cut under sustained yield of 400,000 board feet of sawlogs or 1,000,000 board feet of all products (pulpwood, posts, and chemical wood included) converted to board feet.

Cutting at the rate of 1,000,000 board feet (converted total) will provide 2,250 days of woods work per year 2/ or 3 months' work for 32 forest residents, according to experience records on the Experimental Forest. If 200 days of work a year constitute full-time employment for a worker in forest industries, the 2,250 man-days referred to above will provide 11 such full-time jobs. This means that each 425 acres of forest can

2/ *The large volume of chemical wood removed in logging operations on the Experimental Forest, including wood cut from tree tops, involves considerable hand work and adds materially to the man-days of work provided.*

support one woods worker. In addition, upper Michigan conversion plants using the 1,000,000 board feet will provide about 3,000 days of work per year or enough to support 15 full-time workers.

If the average growth of timber can be increased even 25 percent under good management 105 to 110 board feet per acre, and this is certainly a modest assumption, the annual cut will increase to 500,000 board feet of sawlogs or 1,250,000 board feet of all products. Assuming a market outlet, this will provide 2,810 days of woods work per year, or 3 months' work for 40 forest residents. Upper Michigan conversion plants using this material would provide about 3,800 days' work more or enough to support 19 full-time workers.

Transportation of this volume of timber to conversion plants will, it is estimated, provide full-year employment to 3 workers on the 1,000,000 board feet basis or 4 workers on the 1,250,000 board feet basis. The income paid all these workers would in turn bolster sales of goods and services by trade and professional men in the area.

This is but one illustration drawn from the management records of a 4,700-acre forest. The 50,000,000 acres of commercial forest land in the Lake States, if managed wisely, can provide many such units of employment.

Reproduction in Oak-Hickory Stands

The methods required to reproduce oak in the forests of the southern portion of the Lake States have received little emphasis in the Station's program until recently. Observations made in 1949 clarify some of the problems.

Overstory conditions and past use do not necessarily indicate the kind and quantity of reproduction that becomes established in oak-hickory wood lots in lower Michigan, according to observations made on 176 permanent milacre plots established in eight oak-hickory wood lots. The plots were put in in 1938 by the Soil Conservation Service and reexamined in 1939 and 1949. The wood lots were grazed before the plots were established. One year after grazing was excluded, tree reproduction had doubled in number. However, during the following 10 years, the total number of trees decreased to less than the original number, only white oak and basswood showing any consistent increase.

The ability of tree reproduction to become established differed not only among wood lots but within the same wood lot even though conditions of overstory and past use (cutting, fire, and grazing) were similar. Within individual tracts reproduction commonly was patchy. This may be due to variations in soil moisture. Further study is needed, therefore, of the relation of soil conditions to the establishment and survival of reproduction in oak-hickory stands.

No doubt factors other than soil enter into the failure of oak to reproduce well. Efforts to collect red oak acorns from the 1949 bumper crop in southern Wisconsin[3/] the first week in November disclosed that 60 to 80 percent of the total seed crop had already disappeared. Moreover, from one-fifth to one-fourth of the acorns still remaining were found half buried in mineral soil in or along mice runways.

From these observations it would seem that mechanical scarification of an oak site coincident with a heavy seed crop, which has been suggested as a method of stimulating oak, will not by itself insure satisfactory regeneration. It may be necessary to eliminate or drastically reduce the rodent population or otherwise to protect the acorns. It is suspected that "ideal" forest-floor conditions may also favor rodents, especially mice. Furthermore, plentiful mast is probably accompanied by a population peak of these seed-eating animals which may be sustained at a fairly high level even during years when acorn crops are poor. To test the foregoing theories, it would be desirable for biologists to study population trends and food habits of rodents in oak forests over a period of years.

Age Dispersion in Even-Aged Oak Stands

Some preliminary analyses were made of the age variations between dominant trees in the so-called even-aged mixed oak stands of southern Wisconsin. The following tabulation shows the age dispersion for 211 trees found on 54 1/5-acre sample plots where the northern red oak overstory had an average age of 81 years (76 to 85 "spread" for individual plots):

3/ *This work and also that on age distribution of oak was done in cooperation with the University of Wisconsin and Wisconsin Conservation Department.*

Distribution of Dominant Northern Red Oak According to Total Age

Tree ages	Distribution	
Years	Number	Percent
81 1/	18	8.5
76 - 80	72	34.1
82 - 86	68	32.2
76 - 86 2/	158	74.9
71 - 75	22	10.4
87 - 91	20	9.5
66 - 70	2	0.9
92 - 96	3	1.4
61 - 65	3	1.4
97 - 101	3	1.4
61 - 75) 3/ 87 -101)	53	25.1
Total	211	100.0

1/ Average age class.
2/ Classed as even-aged in terms of range allowed for hardwoods.
3/ Classed as uneven-aged in terms of the range allowed for hardwoods.

The common belief that the mixed-oak forests of southern Wisconsin are essentially even-aged is borne out by this analysis. But every fourth tree comprising the main overstory is from 6 to 20 years younger or older than the average, and in that respect uneven-aged. Silviculturally, this latter point is important for it shows that the period of regeneration in the oak woodlands studied was not confined to one or two years, but took place over a period of approximately two decades. Thus Nature employed her own variation of the shelterwood system in establishing the present-day stands, now in the 80-year-age class, so prominent in the forests of southern Wisconsin.

Although a great deal has been learned, more study is needed to develop better methods for handling most of the timber types in the Lake States. This is especially true of the oak types, a large part of which occur in southern Wisconsin and southern Minnesota where research center facilities are not yet available.

FOREST FIRE RESEARCH

Michigan's Progress in Forest Fire Protection

This history and development of forest fire protection in Michigan from Territorial days to the present, descriptions of major conflagrations of the past, discussions of current problems of forest fire protection, and a summary of state forest-fire statistics - all these are included in a report to be published by the State of Michigan as the result of a comprehensive study of forest fires and forest fire control in Michigan carried on during 1948 and 1949 in cooperation with the Michigan Department of Conservation.

Brought out clearly is the fact that the progress made in controlling Michigan forest fires, particularly in the past twenty years, has been outstanding. Once the classic example of forest devastation, due to widespread forest exploitation and uncontrolled forest fires, Michigan today ranks high among the states for effectiveness in forest fire control. As a result, natural regeneration has taken place on much of the cut- and burned-over land, and the risk of burning (area burned annually) has been reduced to an average of less than 0.2 of 1 percent of the area protected.

With the over-all risk of burning reduced to a nominal figure, the current protection problem is to maintain a high standard of effectiveness and to reduce the number and size of large fires. What makes this so difficult is that the fire season is intermittent and acute fire periods are erratic in occurrence. Whereas the Lake States Burning Index Meter and daily fire weather forecasts provide warnings of emergency conditions, the administrative problem of effectively handling overloads and fires lasting more than 24 hours has not yet been solved.

Fire Protection on the National Forests Improves

An analysis of 12 years' fire and weather records from the eight national forests in the Lake States showed a regular increase in size and number of fires with increased burning index ratings (Station Paper No. 16). Allowing for the severity of conditions prevailing, this study also showed a marked improvement in fire prevention (Technical Note No. 328).

Size of Crew Needed on a Fire

Effective initial attack is the secret of successful fire control. So it is very important to determine quickly the number of men required to control fires in a given time for various combinations of fuel type, travel time, wind velocity, and burning conditions. Such information is provided by a revised set of dispatching tables based on the average rate of spread and rate of control under given conditions. Converting factors are also provided to determine the number of machine units required where power equipment is available.

Minnesota Lags in Protection Expenditures

An analysis of Lake States forest-fire statistics (Technical Note No. 312) showed that the 1948 fire season was unusually severe and the worst since 1936. There were 10.2 fires per 100,000 acres as compared to the 1937-49 average of 6.9. In spite of this, Michigan burned only 0.09 and Wisconsin but 0.15 percent of area protected. Minnesota, on the other hand, burned 0.61 percent, although it had only 8.2 fires per 100,000 acres. This can be related directly to State financial support for fire control. In 1948, Michigan spent 8.7 cents, Wisconsin 5.6 cents, and Minnesota only 3.9 cents per acre. Past years tell the same story. In other words, protection in Minnesota has been adequate only in favorable years.

FOREST ECONOMICS

Forest Survey

Sound forestry plans depend upon an accurate inventory of the forest resource. Such an inventory was made from the three Lake States from 1935-1937, and a reinventory was begun in 1947. The current inventory continued at an accelerated rate in 1949, due to the interest and cooperation of the states and other progressive landowners.

Minnesota Survey About One-Third Completed

In northern Minnesota new infrared aerial photographs were obtained for 2.7 million acres. Field work was continued throughout the year by the Office of Iron Range Resources and Rehabilitation, the State Forestry Division, the U. S. Forest Service, and the Office of Indian Affairs. The Minnesota and Ontario Paper Company, Northwest Paper Company, St. Regis Paper Company, Wood Conversion Company, Diamond Match Company, and several smaller landowners provided seasonal help. The Station worked primarily on growth, drain, and allowable cut. Field work in Minnesota is approximately half done but the job as a whole, including final reports, only 30 percent completed.

Michigan Survey About One-Fourth Done

In Michigan, the Ottawa and Huron National Forests completed field work for their management surveys. A small crew made up of foresters from the Department of Conservation and the Lake States Station finished field work previously started in southwestern Michigan and the western half of the Upper Peninsula. They also covered Luce County and started work in the vicinity of Cadillac. The American Box Board Company and Consumers Power Company are providing help in this area. Reports on southwestern Michigan are being edited and should be available for circulation this spring. About 42 percent of the field work (26 percent of the entire survey job) is completed.

Wisconsin Survey Planned

In Wisconsin, a forest survey steering committee including state, county, federal, and industry representatives, initiated a plan for a 3-year survey of 32 northern counties starting early in 1950. The plan calls for photographing 25,000 square miles and intensively mapping about 12,500 square miles. The State Department of Conservation continued intensive inventories on county forests in Burnett County.

Current Rate of Timber Cutting

Timber cutting in the Lake States continued at a high level during 1948. Station estimates for that year (based on surveys completed in 1949) show that some forest products reached near record highs for the past quarter of a century. Pulpwood production amounted to approximately 2,180,000 cords, only 3 percent less than in 1946 (the biggest production year of record). Other products that maintained high levels of production were sawlogs, box bolts, veneer logs, mine timbers, and excelsior. Very little wood was shipped out of the region in 1948, but considerable quantities of logs and pulpwood were shipped from Minnesota and Michigan into Wisconsin.

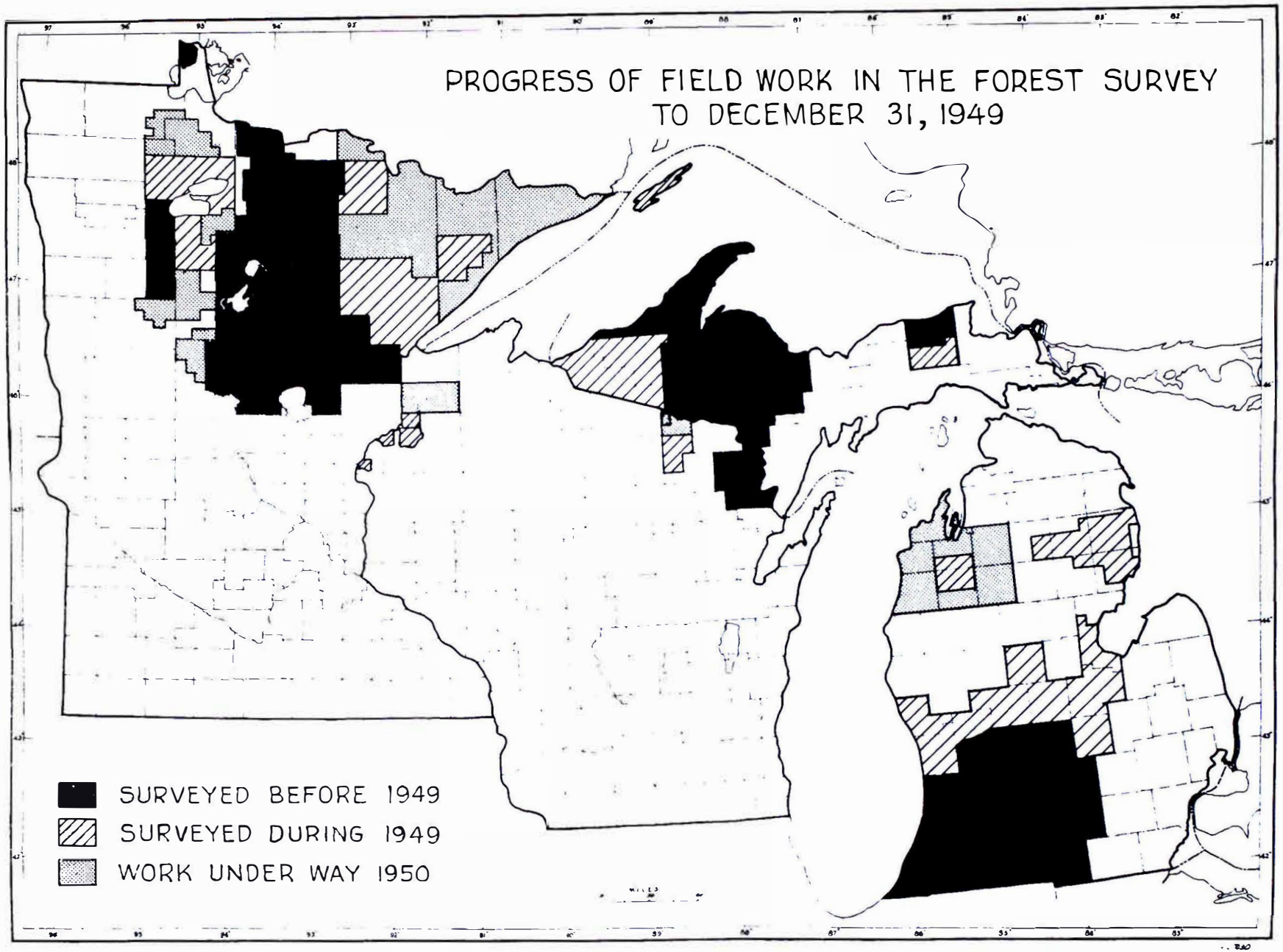
The combined cut for all products resulted in a drain of about 675 million cubic feet of merchantable material from sawlog and pole-timber stands. In the region as a whole, much of the drain (53 percent) was on sawlog-sized trees from which approximately 1-1/2 billion board feet (360 million cubic feet) were cut. However, in Minnesota 65 percent of the total drain in 1948 was on trees of pole-timber size. With the gradual whittling down of the relatively small amount of remaining operable sawlog stumpage, it will not be long before pole-sized trees contribute most of the wood for the many diversified products in the Lake States.

Inventories of State and County Forests

County forests in Minnesota (made up mainly of cut-over tax-forfeited lands) are beginning to emerge as permanent revenue producing properties. Following completion of forest surveys in their area, six northern counties, with the aid of the Iron Range Resources and Rehabilitation office, are preparing sustained-yield management plans with provision for selling merchantable stumpage to local operators. In most cases the income which the counties have obtained has exceeded their forestry expenses. Marinette and Burnett counties, Wisconsin, are engaged in similar constructive planning.

State Forests in Michigan, which heretofore have contributed relatively little in the form of timber products, are being inventoried with the idea of obtaining more complete utilization of available wood.

On the other hand, recent inventories of some Minnesota state forests have indicated need for reduction in rate of logging spruce pulpwood if production is to be maintained. This may be partially offset by balsam fir growth in other localities.


PROGRESS OF FIELD WORK IN THE FOREST SURVEY
TO DECEMBER 31, 1949
SURVEYED BEFORE 1949
SURVEYED DURING 1949
WORK UNDER WAY 1950

U S D A Soil Conservation Service, Milwaukee, Wis

Improved Survey Techniques

Several byproducts of the forest survey have had favorable reception from public and private foresters. Among them are:

1. A "quickie" method for estimating pulpwood volumes on 1/5-acre sample plots (a refinement of methods employed by old-time Maine cruisers) which has been tested by several pulpwood companies and is being employed by at least one county for purposes of timber sale appraisal.

2. A method of estimating "allowable cut" under several levels of growing stock developed for regional survey purposes, which is being used rather widely in preparation of management plans for specific tracts.

3. Species growth rates for Minnesota and Michigan which have been put up in such form that with a little checking and modification they will be applicable to stand and stock tables from other surveys.

4. Many useful conversion factors.

General Resource Situation

Recent survey findings, combined with the results of extensive surveys made by the Station prior to 1937, show that the Lake States region has turned the corner with respect to balance between total growth and drain. More wood is being grown than is cut. However, the size of the trees, the species, and to some extent the location and quality of trees on which most of the growth is being added presents special problems in utilization and management. Landownership is still a complicating factor. These and related matters have been analyzed and discussed in a report "Forest Resources and Forest Industries in the Lake States," now awaiting publication as a government bulletin.

Industry Studies - Pulp and Paper

How important is the Lake States pulp and paper industry in terms of capital investment, annual product, employment, wages, taxes, and contribution to community life? How secure is that industry with respect to needed wood supplies? What is being done to insure adequate future supplies and what more should or could be done in that line? These are questions for which the Station is trying to find answers in its pulpwood study started in 1949.

We know that the 101 paper mills and 46 pulp mills which were operating in the region in 1947, employed approximately 35,000 workers (exclusive of woods workers), paid approximately 112 million dollars in salaries

and wages, and turned out products worth, roughly, 538 million dollars. They are among the region's major manufacturing industries.

We know that the pulp mills have had to pay constantly increasing prices for wood and are faced with a definite shortage of the key species - spruce.

We know that pulpwood forestry has made rather substantial advances in the Lake States during recent years. Many companies have been buying land to block up their holdings. As a result, the aggregate ownership of 18 major operating companies increased from 1,200,000 acres in 1945 to 1,624,000 acres in 1949, an increase of 35 percent.

The industry now employs about 130 foresters in capacities ranging from clerk to general manager, as compared with 27 foresters in 1937. About one-third of the companies engage in forest planting. Many are making surveys and experimenting with improved cutting methods. Most of the landowning companies are aiming at a sustained yield from their own lands to cover from 30 to 50 percent of their raw material requirements, although at present few are getting more than 10 percent.

Concurrently, pulp companies are experimenting with pulping of hardwood species, with closer utilization of spruce, chipping in the woods, and other devices to extend supplies of local woods. Some are even importing pulpwood from the Rocky Mountains at a considerable added cost for freight.

The Station proposes during 1950 to appraise the over-all effect of these various trends upon pulpwood supplies and to determine what may be desirable to safeguard the future of this important industry in the Lake States.

Area Studies - Park Falls Area

Conclusions from the 1948-49 study of this typical area in northwestern Wisconsin were released in Station Paper No. 19, "The Place of Forestry in the Economic Development of the Park Falls Area," July 1949.

The report brings out that northern Wisconsin has made notable progress during the past 15 years in improving the conditions which in the early 30's made it one of the problem areas of the Nation. However, as a result of depletion of the most desirable timber, many localities still face difficult economic conditions.

The report concludes that a solution must be sought through a combination of better forest management and stimulation of the right kind of industries to make full use of the available raw materials. Stabilization of forest landownership, closer integration of farming and forestry, and intelligent management of public lands can each play a part in improving and expanding agriculture and industry in this part of the State.

Financial Aspects of Forestry

Added attention was given to the business aspects of forestry and logging at the Station's four work centers in 1949 and plans were laid for still further emphasis in the future.

Accounting System for Experimental Forests

During the year there was devised a system of records for experimental forests which will provide results of operations in terms comparable with private enterprises. The system takes account of (1) the investment in land and timber; (2) the annual expenditures for maintenance of improvements, protection, and management of timber stands, logging, and taxes (estimated by comparison with adjacent private lands); (3) income from sale of stumpage, logs, and incidental items. Balances will show rate of return on invested capital. The inventories, sales, and cutting records will be broken down by species and kinds of products. Labor costs will be expressed in man-hours as well as dollars. Thus unit costs and returns can be converted whenever hourly wage rates change. The plans call for periodic reinventories to check on increases or decreases in value of property. These accounting systems are being introduced first on the Upper Peninsula Experimental Forest near Dukes, Michigan, and the Cutfoot Experimental Forest on the Chippewa National Forest, Minnesota.

Financial Yields from Pine Forests

A well-stocked pine forest in northern Minnesota can add as much as $3 to $4 annually in stumpage value if properly managed. This has been demonstrated on the Cutfoot Experimental Forest where the volume of merchantable timber is increasing at the annual rate of 235 board feet (Scribner Scale on trees 7-1/2 inches d.b.h. and larger) plus 0.16 cord. At going stumpage rates ($15 per M and $1.50 per cord), this annual increment is worth $3.76 (Technical Note No. 330).

Marketing studies at the Headwaters Research Center brought out the fact that the average 14-inch red pine tree, about 90 years of age, will yield 2.3 times as much stumpage value with fully integrated utilization for all products, as when sold strictly for sawlogs. It will yield more than eight times as much as if sold exclusively as pulpwood. The increased value is obtained by sorting out piling which brings premium prices of 15 to 20 cents per lineal foot and by picking out utility poles and salvaging incidental posts and pulpwood. (Technical Note No. 311.)

Logging Costs

It takes 17-1/2 percent more time and costs correspondingly more to fell and buck a cord of pulpwood from 6-inch jack pine trees than from 9-inch trees, according to time studies made on the Cutfoot Experimental Forest in Minnesota. The detailed breakdown of time

requirements for trees ranging from 5 inches to 15 inches diameter (shown in Technical Note No. 318) should be useful for logging plans, timber appraisals, and forest management work in northern Minnesota.

FARM FORESTRY 4/

Wooden Fence Posts in Minnesota

To develop a fence post from native Minnesota wood that is light, strong, durable, and easy to drive, is the immediate objective of a study begun in the fall of 1948 in cooperation with the Minnesota Agricultural Experiment Station. Results during 1949 included:

1. Tamarack and northern white-cedar posts from 3 to 8 inches in diameter were cold-soaked in a 5-percent solution of pentachlorophenol in small home-treating plants. Tamarack sapwood absorbed the chemical very well in about 48 hours.

   In white-cedar posts, penetration was only about 1/8 inch in three to four days. Penetration was somewhat deeper when the white-cedar posts were incised, but even then the sapwood seldom was completely treated. The method apparently does not work well with cedar but is promising with tamarack. It is already known that jack pine and red pine are easily treated.

2. Treatment of tamarack with a mixture of creosote and pentachlorophenol was also tried, using both hot and cold bath and pressure methods. Results were not as satisfactory as with pine, as only the sapwood seemed to treat satisfactorily. However, since heartwood is naturally durable, tamarack posts treated by this method should compare favorably with treated red or jack pine posts.

3. About 4,000 posts, including creosoted southern pine, ponderosa pine, jack pine, tamarack, and white-cedar; penta-treated white-cedar, and tamarack; and a few steel posts were set in about 10 miles of experimental fence at the Rosemount Research Center, at University Farm, and at the Waseca and Grand Rapids branches of the Agricultural Experiment Station. Tested were various spacings between posts (from 10 to 16 feet), varying types of corners, and several methods of setting the posts (in hand-dug holes, in holes made with a power digger, and hand-driven (steel) or power-driven (wood)).

4/ Some of the results of farm-forestry studies carried out in Wisconsin in cooperation with the Wisconsin Agricultural Experiment Station and the Wisconsin Conservation Department have been reported under "Other Forest Management Studies." No farm-forestry project was carried on in Michigan during 1949.

The use of power diggers produced nearly one hole per minute, but the job of tamping was hard and slow. Driving wooden posts with the power furnished by a lift attachment for the farm tractors, however, was about as rapid as power digging of the holes; and the driven posts were firm in the soil without tamping. Power driving of wooden posts was more rapid than hand driving of steel posts.

4. Insufficient time has elapsed to determine the relative durability of different kinds of posts and types of fencing, but a severe windstorm in October 1949 provided a severe test of their strength and firmness. Large quantities of debris caught by the fences made them subject to the full force of the gale. Fences supported by sound wooden posts stood up well, while those supported with steel posts were severely damaged by bending. Some of the set wooden posts were loosened in the ground and staples were pulled from a few. However, one newly completed fence of driven wooden posts exposed to the full force of the storm was undamaged.

FOREST WILDLIFE RESEARCH

(Conducted by Fish and Wildlife Service in cooperation with the Forest Service)

Ecological Study of the Moose on Isle Royale National Park (Michigan)

Observations on the condition of the range show that it degenerated a great deal since the browse survey of May 1948. Heavy browsing is much more widespread and there is a noticeable increase in the amount of dead browse, especially aspen and willow. Browsing of white-cedar was noted in many more localities and in some, utilization was heavy. Hazel received heavier usage and speckled alder was browsed for the first time. Large numbers of standing aspen were barked for the first time in widely scattered areas, as were some speckled alder and tamarack, a sign of increased range use. Observations on the physical condition of the moose showed that many came through the winter in poor condition. The die-off, forecast last year, also became a reality. Ten dead moose were found in the spring and six more in the fall. That the die-off was widespread was indicated by the findings of carcasses in almost every section of the island. Examinations of the carcasses, including the teeth, indicated that it was not a normal die-off of older animals.

Deer Range Examinations

Deteriorating winter deer browse conditions were revealed by a survey made in five key wintering areas on the Superior National Forest in cooperation with the Forest Service and state biologists. These areas were first surveyed in 1940 and 1942, and the objective was to compare these findings with the 1949 results to determine changes in the vegetation during the period. A study of the browse data for all yards

(1940 and 1942) shows that the ten top ranking foods in order of their importance to deer were: mountain-maple, redosier dogwood, hazel, white-cedar, mountain-ash, paper birch, elder, willow, honeysuckle, and pin cherry. They form 95.8 percent of the deer food during the winter period. In 1949 the survey showed that 94.9 percent of the food eaten was made up of the following species: mountain-maple, hazel, thimbleberry, honeysuckle, balsam fir, redosier dogwood, mountain-ash, paper birch, hard maple, and soft maple. Seventy-five percent of the available food supply at present is made up of mountain-maple, hazel, thimbleberry, honeysuckle, and balsam fir. Only one of these species, mountain-maple, is a first-rate food. In four of the yards the range is overbrowsed and is getting worse each year. The range has improved in one yard in which the winter population has been reduced. The available browse now amounts to about half of what it was in 1940 and 1942. The index of browsing for all yards shows that the 100 mark is being approached or passed for the choice kinds of browse. At the same time utilization of starvation or second-rate foods has greatly increased.

Birds and Mammals Affect Seed Germination

Published in Ecological Monographs for July 1949 were the results of a study the objective of which was to present the results of controlled laboratory experiments with seeds recovered from the digestive tracts of various birds and mammals. In eight out of the sixteen species of seed tested after recovery from bird droppings, germination was definitely improved. It is, therefore, clear that in these species, and doubtless in many others, consumption of their fruit by birds not only assures dispersal of the seed, but due to the improved germination also increases the chances of seedling establishment. Although none of the seed recovered from mammal scats appeared to have benefited from the digestive action, much of it was still germinable. Since the animals studied consume considerable quantities of these fruits, their importance at least as agents of seed dispersal is obvious.

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PERSONNEL

LAKE STATES FOREST EXPERIMENT STATION

As of December 31, 1949

Administration - Elwood L. Demmon, Director
Jerry Roch, Administrative Officer
Charlotte L. Devine, Clerk
Helen A. Woodworth, Clerk-Stenographer
Dorothy A. Keller, Clerk
Mary H. Seaman, Clerk
Adele M. Gibney, Clerk-Stenographer
M. Evelyn Wright, Stenographer

Forest Management - Francis H. Eyre, Forester, In Charge
Paul O. Rudolf, Forester
Suren R. Gevorkiantz, Forester
Lucille P. Olsen, Statistician

Field Stations

Headwaters Forest Research Center, Grand Rapids, Minnesota
Lawrence P. Neff, Forester, In Charge
Zigmond A. Zasada, Forester
Eugene I. Roe, Forester
Robert A. Ralston, Forester (Effective 7/11/49)
Lee S. South, Forestry Aide
Archie V. English, Clerk

Northern Lakes Forest Research Center, Rhinelander, Wisconsin
Joseph H. Stoeckeler, Forester, In Charge
Carl Arbogast, Jr., Forester
Miron L. Heinselman, Forester
Edward R. Stoltz, Clerk

Lower Peninsula Forest Research Center, East Lansing, Michigan
John L. Arend, Forester, In Charge (Effective 2/14/49)
LaMont G. Engle, Forester
James J. Kellis, Clerk (Effective 8/29/49)

Upper Peninsula Forest Research Center, Marquette, Michigan
Walter M. Zillgitt, Forester, In Charge
Franklin R. Longwood, Forester (Effective 6/10/49)
Wilho A. Salminen, Forestry Aide
Gloria D. Matson, Clerk (Effective 10/10/49)

Dakota Plains Forest Research Center, Denbigh, North Dakota
Inactive

Forest Influences - Carlos G. Bates, Forester (Deceased 7/22/49)

Fire Control - J. Alfred Mitchell, Forester
John S. Crosby, Forester

Forest Economics - Russell N. Cunningham, Forester, In Charge

Economics of Management and Utilization
Howard W. Mayne, Forester

Forest Survey
Arthur G. Horn, Forester
Clarence D. Chase, Forester
Paul C. Guilkey, Forester
Harvey M. Seeley, Forester

Statistics
Suren R. Gevorkiantz, Forester
Lucille P. Olsen, Statistician

Cooperative Farm Forestry
Michigan - John W. Creighton, Jr. (through 6/30/49)

Minnesota - John R. Neetzel, Forester

Wisconsin - Harold F. Scholz, Forester

Forest Biology (Fish & Wildlife Service, U. S. Department of Interior)
Laurits W. Krefting, Biologist
Sophie M. Prince, Clerk-Stenographer